DRAFT-FINAL
WORK PLAN TO PREPARE
BASELINE RISK ASSESSMENTS
AT 16 SWMUS,
REDSTONE ARSENAL

Prepared for:

U.S. ARMY CORPS OF ENGINEERS
HUNTSVILLE DIVISION

Prepared by:

ENVIRONMENTAL SCIENCE & ENGINEERING, INC.
Gainesville, FL

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LIST OF ACRONYMS

ARAR	applicable or relevant and appropriate requirement
AWQC	ambient water quality criteria
bls	below land surface
BRA	baseline risk assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMS	Corrective Measures Study
COPC	chemical of potential concern
CSF	cancer slope factor
EPA	U.S. Environmental Protection Agency
ESE	Environmental Science & Engineering, Inc.
FS	feasibility study
G&M	Geraghty & Miller, Inc.
HEA	Health and Environmental Assessment
HEAST	Health Effects Assessment Summary Tables
HI	Hazard Index
IRIS	Integrated Risk Information System
MCL	maximum contaminant level
NAAQS	national ambient air quality standard
NCP	National Contingency Plan
NPL	National Priority List
PRG	preliminary remedial goal
QA/QC	quality assurance/quality control
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act of 1976, with Amendments
RfC	reference concentration
RfD	reference dose
RFI	RCRA Facility Investigation

LIST OF ACRONYMS
(Continued, Page 2 of 2)

RME	reasonable maximum exposure
RSA	Redstone Arsenal
SWMU	solid waste management unit
UCL95	upper ninety-fifth confidence limit on the mean
USABRDL	U.S. Army Biomedical Research and Development Laboratory
USACE	U.S. Army Corps of Engineers
USACMDAT	U.S. Army Chemical Munition Demilitarization Agency
USAEHA	U.S. Army Environmental Hygiene Agency

1.0 INTRODUCTION

The U.S. Army Corps of Engineers (USACE) has contracted with Environmental Science & Engineering, Inc. (ESE) to conduct three human and ecological baseline risk assessments (BRAs) to address contamination detected at 10 study areas, comprising 16 solid waste management units (SWMUs), at the Redstone Arsenal (RSA) in Madison County, Alabama (see Figure 1-1). The purpose of a BRA is to determine if remedial action is required at the 10 study areas by assessing the potential health risks to humans and ecological receptors that may be posed by these areas.

RSA has conducted studies of past hazardous waste management practices at its facility in accordance with the requirements of the Resource Conservation and Recovery Act of 1976, with Amendments (RCRA). These studies included a RCRA Facility Investigation (RFI) and Health and Environmental Assessment (HEA) [Geraghty & Miller, Inc. (G&M); 1991, 1992], and a Draft Corrective Measures Study (CMS) (ESE, 1993). These studies were conducted on the 16 SWMUs listed in Table 1-1 and shown on Figure 1-2. While the draft CMS report was being completed for an April 1993 submittal to the U.S. Environmental Protection Agency (EPA), RSA was proposed to be listed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priority List (NPL). As a result, EPA Region IV requested that RSA revise both the RCRA HEA (conducted as part of the RFI (G&M, 1991, 1992) and the RCRA CMS (ESE, 1993) to meet the requirements for their equivalent documents under CERCLA and the National Contingency Plan (NCP). Thus, the BRA will require additional evaluations of HEA conclusions and revisions to reflect CERCLA requirements for a BRA, while the CMS requires further evaluations and revisions to reflect the requirements for a CERCLA feasibility study (FS).

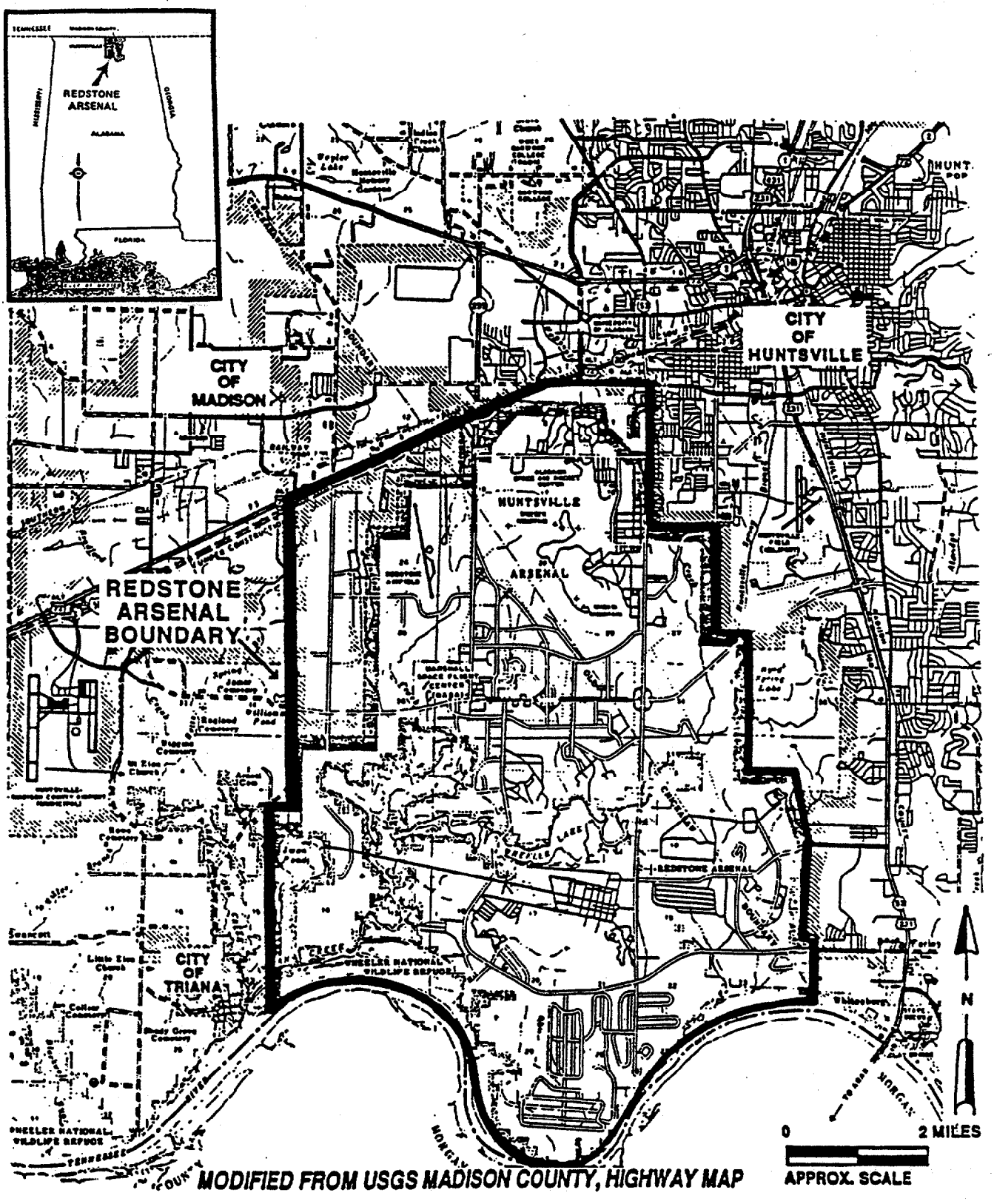

Figure 1-1
LOCATION OF REDSTONE ARSENAL, ALABAMA

SOURCE: G&M, 1991.

REDSTONE ARSENAL

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Table 1-1. SWMUs to be Evaluated in the Baseline Risk Assessments at RSA

Site	RSA Area	RSA SWMU No.	BRA No.	Unit Description
Unit 1		10	2	Active Inert and Closed Landfill - Closed Disposal Trenches, Closed Waste Oil Pits
Unit 2				Active Open Burn/Open Detonation Area
		12	3	Open Burn Pans
		13	3	Unlined Open Burn Areas
		14	3	Waste Burn Trenches
		131	3	Open Detonation Area
		132	3	Former Popping Furnace
		133	3	Former Rocket Washout Pad
Unit 3	F	49	1	Former Arsenic Ponds
	G	48	1	Former Sanitary and Industrial Landfill
	Q3	53	2	Former Sanitary and Industrial Landfill
	Q4	60	2	Former Sanitary and Industrial Landfill
	R	59	1	Former Industrial Landfill
	S/T	55/54	1	Former Industrial and Sanitary Landfill
	X1	66	3	Former Ash Disposal and Demolition Area
	Z	68	3	Former Industrial Waste and Ordnance Disposal and Demolition Area

Source: ESE.

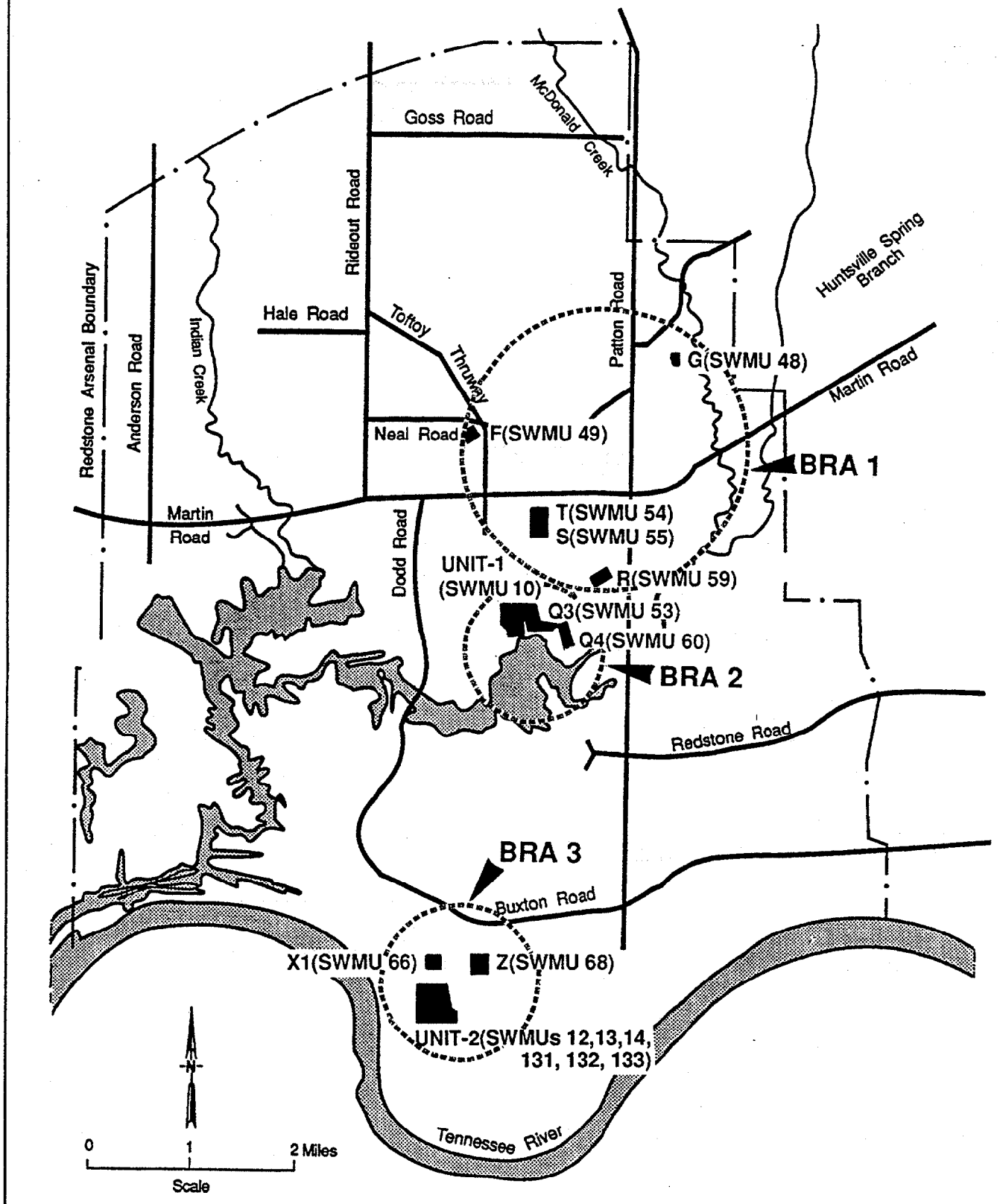

Figure 1-2
LOCATION OF 16 SWMUs INCLUDED IN BASELINE RISK ASSESSMENTS AT REDSTONE ARSENAL, ALABAMA
SOURCES: G&M, 1991; ESE.

REDSTONE ARSENAL

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This report presents a work plan to prepare BRAs for the 16 SWMUs. A work plan to prepare FS documents at these sites will be presented under separate cover. The BRAs for the 16 SWMUs will be prepared and submitted in three separate documents:

1. BRA 1--RSA SWMUs 49 (Area F), 48 (Area G), 59 (Area R), 55/54 (Area S/T).
2. BRA 2--RSA SWMUs 10 (Unit 1), 53 (Area Q3), and 60 (Area Q4).
3. BRA 3--RSA SWMUs 12, 13, 14, 131, 132, 133 (Unit 2); 66 (Area X1); and 68 (Area Z).

Where possible, the study areas have been grouped according to various factors including geographical proximity (see Figure 1-2), similarities in site contaminants, and similarities in human and/or ecological receptors. For instance, the three landfill SWMUs located in central RSA were combined to form Group 2, primarily to take advantage of similarities in site contaminants and potential receptors. Another advantage of combining these three SWMUs into Group 2 is the potential for significant groundwater remediation cost savings by implementing a centralized treatment system. This same approach was used to create Group 3, which combines geographically proximate sites with similar groundwater contaminants and similar potential receptors. The Group 3 SWMUs also provide an opportunity to implement a centralized groundwater treatment system. The remaining five SWMUs were combined into Group 1, based on RSA's priority ranking of sites. Information and analytical data obtained during previous site investigations will be used to support the preparation of the BRAs for the 16 SWMUs.

1.1 WORK PLAN ORGANIZATION

This work plan consists of three sections: introduction, BRA preparation, and sequence of deliverables. Section 1.0, Introduction, presents a brief overview of background information. A more detailed description of site background information is presented in the RFI documents (G&M, 1991, 1992). These

documents should be reviewed for information about the detailed field protocols, laboratory analysis procedures, and contamination assessment methodologies employed during those efforts to provide a better understanding of the site investigation results. Section 2.0, Baseline Risk Assessment, describes the preparation of the BRA, and Section 3.0, Deliverables, identifies the sequence of deliverables. The technical approach used to conduct the BRA is described in the following sections.

2.0 BASELINE RISK ASSESSMENT

ESE will conduct the three BRAs based on EPA's Risk Assessment Guidance for Superfund (RAGS) (EPA, 1989a, 1989b, 1991b) and related agency-wide guidelines (e.g., Exposure Assessment Guidelines). Relevant Alabama guidance and local concerns will also be considered. The purpose of the BRA is to evaluate the potential for chemicals associated with the site to cause adverse effects on human health and ecological receptors in the absence of any remedial action. The BRA results will be used during the FS to identify effective remedial alternatives that will mitigate these risks, if necessary, and to determine preliminary remediation goals (PRGs). The BRA will follow the general outline presented in Table 2-1.

The human BRA will be conducted based on EPA's RAGS, Volume I, Part A, Human Health Evaluation Manual (EPA, 1989a), published supplements to this manual, and relevant EPA guidance regarding exposure and toxicity assessments. The ecological BRA will be conducted based on RAGS, Volume II, Environmental Evaluation Manual (EPA, 1989b), Ecological Assessment of Hazardous Waste Sites (EPA, 1989c), ECO Updates (issued intermittently by EPA to supplement RAGS), and relevant EPA guidance on exposure and toxicity assessments. Apparent concerns at RSA include the onsite presence of rare, threatened, or endangered species; the importance of onsite aquatic and riparian habitats associated with the Tennessee River; and onsite wetlands. Information currently available will therefore be evaluated to characterize the ecotoxicity effects of site contaminants. Information will also be developed as part of the FS to evaluate the effects of potential remedial activities on wetland function, and to determine the means by which those impacts may be mitigated during the remedial phase.

EPA ecological risk assessment guidance indicates that identification of data gaps/needs is a critical step, which cannot be performed without a screening procedure. This screening will be accomplished for the RSA BRAs based on EPA

Table 2-1. General Outline of BRA

1.0	INTRODUCTION - Overview - Site Background - Scope of Risk Assessment
2.0	HAZARD IDENTIFICATION - General Site-Specific Data Collection Considerations - General Site-Specific Data Evaluation Considerations - Summary of Chemicals of Potential Concern - Uncertainties
3.0	EXPOSURE ASSESSMENT - Characterization of Exposure Setting - Identification of Exposure Pathways/Fate and Transport Analysis - Quantification of Exposure - Uncertainties
4.0	TOXICITY ASSESSMENT - Definition of Terms - Summary of Noncarcinogenic, Carcinogenic, and Ecotoxic Dose-Response Information - Develop Toxicity Profiles for COCs (As an Appendix) - Uncertainties
5.0	RISK CHARACTERIZATION/CLEANUP GOALS - Methods for Human Risk Characterization - Current Human Carcinogenic Risks - Current Human Noncarcinogenic Hazard Indices - Future Human Carcinogenic Risks - Future Human Noncarcinogenic Hazard Indices - Methods for Ecological Risk Characterization - Current Ecological Effects - Future Ecological Effects - Uncertainties
6.0	SUMMARY OF RESULTS - Hazard Identification - Exposure Assessment - Toxicity Assessment - Risk Characterization/Cleanup Goals

Source: ESE.

risk assessment guidance. The screening approach uses the available data and conservative assumptions to identify potential problems and data gaps. If the conservative screening does not identify potential problems or data gaps, then no further ecological risk assessment is required. If the screening identifies specific problems or data gaps, recommendations will be made for specific additional activities to be performed during the remedial design stage. The ecological screening procedure will ensure that any recommendations for further activities are focused only on actual ecological risks. A summary of the technical approach for each element of the BRA, as listed in Table 2-1, is presented in the following paragraphs.

2.1 INTRODUCTION

To provide a general understanding of the site history and site conditions, the introductory sections of the BRA will summarize information from the RFI and CMS reports to include the following sections:

1. Site Overview,
2. Site Background, and
3. Scope of BRA (Conceptual Site Model).

A conceptual site model will be prepared (see Figure 2-1) and included in the description of the scope of work. This model is a graphical representation of the environmental system and the biological, physical, and chemical processes that determine the transport of contaminants from sources at the site through environmental media to receptors within the system. The conceptual site model allows for the identification of the major contaminant sources, potential exposure pathways, and receptors. Following the development of the conceptual site model, the remaining elements of the BRA will be conducted which include the following:

1. Hazard Identification,
2. Exposure Assessment,
3. Toxicity Assessment,

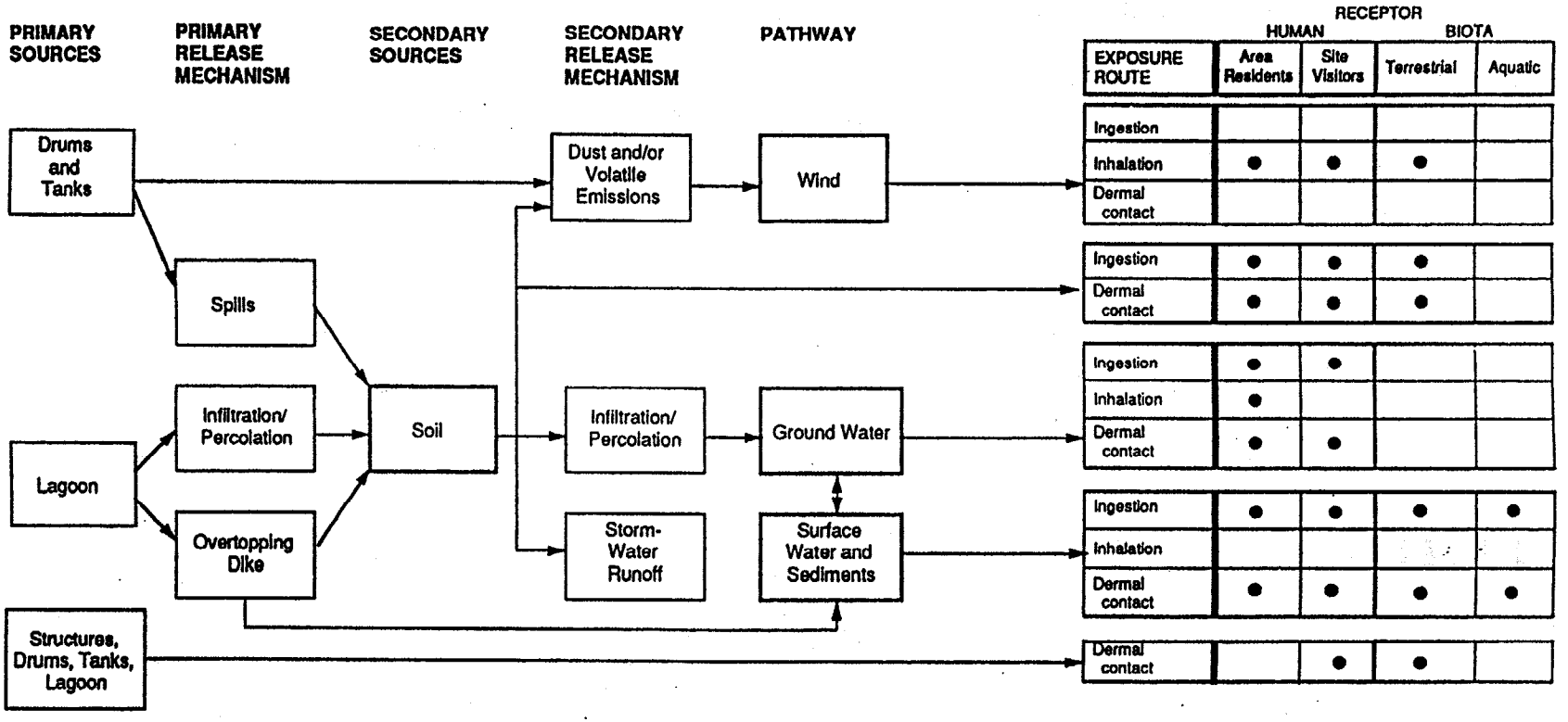

Figure 2-1
EXAMPLE OF A CONCEPTUAL SITE MODEL

SOURCE: EPA, 1988.

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4. Risk Characterization/Cleanup Goals, and
5. Summary of BRA Results.

The human and ecological BRA activities will be coordinated and presented together as one report. The proposed procedures for the human and ecological BRAs will be addressed separately under each primary subheading.

2.2 HAZARD IDENTIFICATION

The primary objective of this element is to identify chemicals of potential concern (COPCs) whose site-specific risks will be assessed. To meet this objective, EPA risk assessment guidance requires that hazard identification be conducted following two steps: data collection and data evaluation. The data collection step involves obtaining all relevant analytical data from site investigations and sorting by medium to include background samples, quality assurance/quality control (QA/QC) samples, sampling methods and detection limits, special analytical services, and sampling locations. The data evaluation step involves evaluation of the analytical methods used; the quality of the data with respect to sample quantitation limits, data qualifiers, and codes; blanks; and tentatively identified compounds. Data evaluation also entails comparing potential site-related contamination with background.

As cited in the RFI (G&M, 1991, 1992), the data collection and data evaluation steps were conducted as part of the RFI according to RAGS (EPA, 1989a); therefore, this information will be directly incorporated into the BRA. The BRA will provide a description of the data set used and a listing of COPCs by media for each site.

The list of COPCs for the ecological BRA will be a subset of the COPCs identified for the human health BRA. COPCs for the ecological assessment will be selected in consideration of data availability to characterize chemical-specific toxic effects

to nonhuman receptors and their tendency to bioaccumulate, which may result in exposure to humans or high-level predators.

2.3 EXPOSURE ASSESSMENT

The purpose of the exposure assessment is as follows:

1. Identify and characterize receptor populations, including potentially sensitive subpopulations such as children;
2. Describe the fate and transport of COPCs;
3. Identify current and future exposure pathways (an exposure pathway is comprised of a chemical source, an environmental transport medium to a point of potential exposure, a receptor, and an exposure route); and
4. Estimate exposure (intake) for each significant subpopulation and pathway based on Reasonable Maximum Exposure (RME) scenarios.

2.3.1 HUMAN EXPOSURE ASSESSMENT

The RFI (G&M, 1991) for the 16 SWMUs already contains the information required for the human exposure assessment section of the BRA. These sections will therefore be obtained from the RFI and incorporated directly into the BRA. These sections will include:

1. Description of the components of the current human exposure pathways (tabular form),
2. Chemical migration pathways (tabular form), and
3. RME exposure concentrations for all environmental samples (e.g., groundwater, surface water, sediment, shallow soil, deep soil, and test pit samples).

Additional elements not previously addressed in the RFI that will be included are:

1. Description of future human and ecological exposure pathways (tabular form),
2. Qualitative assessment of the chemical and physical properties of site-related chemicals and the associated affects on chemical transport,

3. Identification of exposure factors for all exposure scenarios, and
4. Quantification of all significant exposure routes (i.e., ingestion, dermal absorption, inhalation) associated with significant exposure pathways.

Potential exposure pathways will be identified and subsequently screened to determine whether quantification of the pathway is warranted. Pathways will be eliminated if they can be shown to be incomplete. This screening process will be documented in tabular form, identifying the pathways considered and reasons for selection or exclusion. In some cases, this screening has already been completed as part of the RFI and the rationale will be adopted as part of the BRA. Additional screening will be conducted based on ecological considerations and an evaluation of the exposure factors identified for each potential exposure scenario (i.e., if area is paved, there is no exposure to suspended dust).

RME chemical intakes will be quantified using equations presented in, or adapted from, RAGS (EPA, 1989a, 1991b) for the exposure routes of concern based on values presented in RAGS (EPA, 1989a) and Supplemental Guidance "Standard Default Exposure Factors" (EPA, 1991b). Site-specific factors identified in consultation with USACE (i.e., worker exposure factors) will also be used to calculate current chemical intakes.

Exposure concentrations have already been determined in the RFI for all chemicals detected in surface soil, deep soil, groundwater, surface water, and sediment. Although the RFI states that the RME exposure concentrations were developed according to RAGS (EPA, 1989a) certain exclusions to defined RAGS protocol have been identified, including use of filtered groundwater samples and collection of surface soil samples from 0 to 18 inches below land surface (bls). The BRA documents will evaluate the appropriate application of this data and qualify BRA conclusion impacts. Surface soil, deep soil, groundwater, surface water, and sediment characterization concentrations will be used directly from

the RFI in the BRA to calculate chemical-specific intakes for all relevant exposure scenarios and exposure routes.

2.3.2 ECOLOGICAL EXPOSURE ASSESSMENT

Information obtained from site visits and previous site investigations will be used to describe habitats and receptor populations present and potentially affected by COPCs. Important site-specific information to be described includes habitat areas and use by potentially important receptors. The current literature is also important in describing behaviors of receptors that affect exposure such as predator/prey relationships, migrations, diurnal movements, home ranges, and life-cycle patterns. This information will be used to select a subset of potential nonhuman receptors for a more detailed risk evaluation. This selection will be based on ecological and/or economic importance; trophic positions and potential for exposure; rare, threatened, or endangered status; and sensitivity to COPCs.

To the extent appropriate, the ecological BRA will use the same exposure concentrations as the human BRA. There are numerous instances in which the same concentrations are not representative of exposure levels for both human and nonhuman receptors, when differences in activity patterns or the duration of exposure necessary to produce a toxic effect are considered. Full rationale for data application will be provided in the BRA submittal. Groundwater contaminant concentrations are not directly relevant to the ecological BRA.

Potential exposure pathways will be described. Doses will be estimated using conservative ecological exposure scenarios for selected receptors and pathways. Animal home range, migratory patterns, etc., will be considered in developing exposure scenarios for localized contamination.

2.4 TOXICITY ASSESSMENT

2.4.1 HUMAN TOXICITY ASSESSMENT

The toxicity assessment describes the toxicological properties of the COPCs, including their pharmacokinetics, metabolism, acute and chronic toxicity, carcinogenic and noncarcinogenic effects on human receptors, wildlife, and aquatic species (carcinogenic effects are typically evaluated only for human receptors). This information will be obtained for those chemicals contributing significant site risks. The information will be obtained from available computerized data bases and other accepted sources. For chemicals not previously addressed, new profiles will be written using EPA's Integrated Risk Information System (IRIS) data base as the primary source of toxicological information which ESE accesses via a CD-ROM which is updated quarterly. IRIS will be used to determine EPA reference doses (RfDs), reference concentrations (RfCs), cancer slope factors (CSFs), and applicable or relevant and appropriate requirements (ARARs) such as federal maximum contaminant levels (MCLs), ambient water quality criteria (AWQC), and national ambient air quality standards (NAAQS). EPA's Health Effects Assessment Summary Tables (HEAST) will be used as a secondary information source for RfDs and CSFs if they are not available in IRIS. If neither source identifies an appropriate toxicological constant, current literature will be obtained in consultation with USACE, and will be reviewed to identify appropriate toxicological data which will be used to calculate an RfD using methodologies outlined in EPA guidance documents.

Because there are military-specific compounds (i.e., ordnance and explosive waste, chemical warfare material) present or suspected at RSA, supplemental toxicological information may be obtained from several Army agencies, such as the U.S. Army Biomedical Research and Development Laboratory (USABRDL), the U.S. Army Environmental Hygiene Agency (USAEHA), and the U.S. Army Chemical Munition Demilitarization Agency (USACMDA) to ensure that current data and interpretations are used in determining the risk of military-specific chemicals.

2.4.2 ECOLOGICAL TOXICITY ASSESSMENT

Ecotoxicity information will be presented as part of the chemical-specific interpretive toxicological profiles developed for human toxicity. Ecotoxicity aspects are presented in coordination with human health data to avoid redundancy, but will be appropriately referenced to facilitate location of data by reviewers. Profiles will include physical and chemical properties, acute and chronic toxicity test results on aquatic and terrestrial organisms, relevant standards and criteria, and the potential for bioaccumulation. Data are summarized to emphasize receptors associated with the site or closely related taxa to the extent possible. Ecotoxicity endpoints (toxicity benchmarks relevant to population or ecosystem structure or function, such as reproductive impairment or reduction in growth rate) will be selected for each COPC.

2.5 RISK CHARACTERIZATION

The primary objective of risk characterization is to determine point estimates of current and future human and ecological health effects.

2.5.1 HUMAN RISK CHARACTERIZATION/CLEANUP GOALS

Risk characterization integrates the quantitative results of the toxicity and exposure assessments to produce a quantitative estimate of risk. Carcinogenic risks will be presented as the incremental individual lifetime probability of experiencing cancer; while noncarcinogenic endpoints are expressed as Hazard Indices (HIs), calculated as the ratio of the estimated intake to the RFD. A tabular format will be used for these point estimates.

The risk characterization will also include a section on identification/ development of cleanup goals. Cleanup goals are health-based, media-specific levels that represent the highest chemical-specific concentrations that can remain at a site without posing significant health risks. The cleanup levels will be derived based on methods presented in RAGS, Part B, Development of Risk-based Preliminary Remedial Goals (PRGs) (EPA, 1991a). PRGS are developed for those

chemicals posing unacceptable risks considering site-specific exposure information such as the type of exposure expected at a site. Thus, in the absence of promulgated standards, health-based cleanup goals serve as guidance to determine the necessary level of cleanup of different media at a site to be protective of human health. Developing cleanup goals in this manner ensures that the overall additive noncarcinogenic health effects or cancer risk associated with a mixture of compounds present at a site is protective even if no individual compound poses potential noncarcinogenic or carcinogenic effects. The cleanup goals will be presented in tabular form in the main body of the text; the algorithms used to determine the goals will be presented as an appendix.

2.5.2 ECOLOGICAL RISK CHARACTERIZATION/CLEANUP GOALS

Where site data are sufficient and appropriate ecotoxicity endpoints are available, potential for adverse effects to individuals may be quantified, and the results of an adverse effect may be extrapolated to population, communities, and the ecosystem. Ecological risk is characterized using toxicity quotients (e.g., EPA, 1986); these are similar to the HIs used to evaluate the potential for noncarcinogenic effects in human health assessments. According to EPA guidance, qualitative evaluation is sufficient for some pathways and receptors. Additionally, the potential effects to habitats and/or ecosystems will be described. These may include considerations in addition to the effects attributable to direct or indirect exposure to COPCs, such as physical disturbance associated with remedial activities.

For those chemicals posing unacceptable risks to ecological receptors, cleanup goals will be developed. These goals represent the highest chemical-specific concentrations that can remain at a site without posing significant adverse effects to ecological receptors. The cleanup levels will be derived based on RAGS (EPA, 1989b) and published literature on ecological risk assessment. In the absence of promulgated standards, health-based cleanup goals will serve as guidance to determine the necessary level of cleanup of different media at a site to be

protective of ecological receptors. The cleanup goals will be presented in tabular form in the main body of the text; the algorithms used to determine the goals will be presented as an appendix.

2.6 SUMMARY OF RESULTS

This section provides a summary of the results of the HI, exposure assessment, toxicity assessment, and risk characterization/cleanup goal steps of the BRA. A qualitative discussion of the uncertainties inherent in the BRA process, emphasizing the most important sources of uncertainty, will also be included. Uncertainty analysis provides a perspective on the significance and reliability of each step, and provides useful guidance in the decision making concerning appropriate remedial actions. For example, the implication of adopting exposure concentrations (UCL95 values) as described in Section 2.3.1, will be evaluated to determine the potential impacts on results viability.

For the human BRA, factors contributing to uncertainty in the overall BRA will be highlighted, including uncertainties introduced by limitations in site-specific data, toxicity data for the COPCs, and existing and probable future intake estimations. The ecological BRA is also subject to uncertainties. Assumptions are usually made to simplify the assessment and to eliminate data gaps. These uncertainties may place limits on the proper use of the conclusions drawn from the results. This section explains the limitations by providing variance estimates for statistics, listing and rationalizing assumptions, describing potential sources of error, and places these uncertainties within the context of naturally occurring ecological variability.

3.0 DELIVERABLES

As previously described, the BRAs for the 16 SWMUs under consideration will be prepared and submitted according to the following three groups:

1. BRA 1--RSA SWMUs 48, 49, 54/55, and 59 (Areas F, G, R, and S/T);
2. BRA 2--RSA SWMUs 10, 53, and 60 (Unit 1, Areas Q3, and Q4); and
3. BRA 3--RSA SWMUs 12, 13, 14, 66, 68, 131, 132, and 133 (Unit 2, Areas X1, and Z).

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